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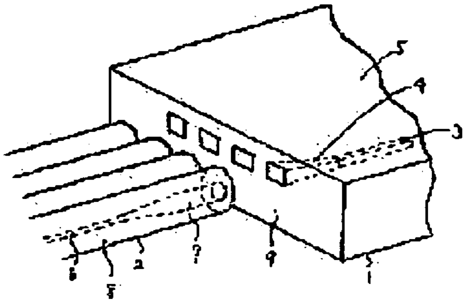
(54) OPTICAL WAVEGUIDE, CONNECTING DEVICE FOR OPTICAL WAVEGUIDE AND OPTICAL FIBER

(57)Abstract:

PURPOSE: To provide the optical waveguide with which the accuracy of alignment is made less severe and further, low-loss connection is possible by increasing the spot size of light in the input/output part of an optical waveguide in connection of the optical waveguide and optical devices.

CONSTITUTION: Optical fibers 2 which are expanded in cores 6 are used. The cores 3 in an optical waveguide substrate 1 are also so formed that the cores are larger toward the input/output end face 9 of the optical waveguide. As a result, the respective spot sizes of the light of the optical fibers and the optical waveguide are enlarged. The loss by the mispositioning of the expanding parts 7 of the optical fibers and the expanding parts 4 of the cores of the optical waveguide is smaller than in the case the spot sizes are not expanded.



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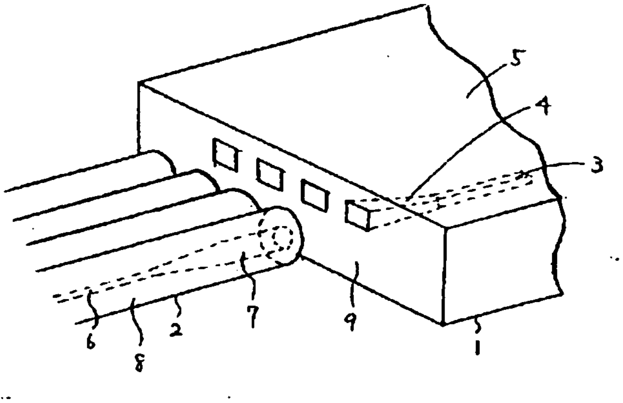
(54)【発明の名称】　光導波路、光導波路と光ファイバの接続装置

(57)【要約】

【目的】光導波路と光デバイスの接続において、光導波路の入出力部での光のスポットサイズを大きくすることによって、位置合わせの精度を緩くし、さらに低損失な接続を行える光導波路を提供することを目的とする。

【構成】光ファイバ２はコア６を拡大したものを用い、光導波路基板１内のコア３も光導波路の入出力端面９に向かうにしたがってコアが大きくなるように構成されている。それらにより光ファイバと光導波路のそれぞれの光のスポットサイズを拡大し、光ファイバのコアの拡大部７と光導波路のコアの拡大部４の位置ずれによる損失は、スポットサイズを拡大しない場合に比べて小さくなる。



【特許請求の範囲】

【請求項１】光が伝搬する複数のコアが光導波路基板に整列形成された光導波路において、前記光導波路の入出力部においてコアが拡大されて、伝搬光がスポットサイズを拡大されて入出力されることを特徴とする光導波路。

【請求項２】光導波路基板内に光を伝搬する伝搬用コアが形成された光導波路において、前記伝搬用コアの端部に接続する、該伝搬用コアよりも断面積が大きくて屈折率が小さな１あるいは複数の結合用コアが形成され、前記結合用コア端が光導波路の入出力部とされたことを特徴とする光導波路。

【請求項３】光が伝搬する複数のコアが光導波路基板に整列形成された光導波路と、整列された複数の光ファイバとが接続される光導波路と光ファイバの接続装置において、前記光導波路と光ファイバとは接続部においてそれぞれのコア径が拡大されて、伝搬光がスポットサイズを拡大して入出力されることを特徴とする光導波路と光ファイバの接続装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、光デバイスと光入出力の接続を行うための光導波路に関する。

【０００２】

【従来の技術】図１２は従来の一般的な光導波路と光ファイバの接続構造を示したもので、光導波路のコア３と光ファイバのコア６を直接突き合わせる方法を用いていた。

【０００３】

【発明が解決しようとする課題】しかしながら、上記の接続方法を用いる場合、光導波路と光ファイバの光のスポットサイズは１０μm程度と小さく、低損失な接続を行うためには高精度の位置合わせを必要とする。また、２組以上の光導波路と光ファイバを接続する場合には図１３のようなＶ溝基板１３に光ファイバ２を整列させたものを使用する。この時、接続による損失を小さくするには、先に述べた高精度の位置合わせの他に、光ファイバ２のコア６と光導波路のコアの間隔を等しくし、さらに間隔にばらつきがあってはいけない。よって、Ｖ溝１４は精度の良いものが要求されるが、実際には作製が困難で、また作製できても価格の高いものになってしまう。また、光ファイバ２のクラッド８の大きさやクラッド８の外形に対するコア６の同芯度やそのばらつき、さらには光ファイバ２のＶ溝１４への固定の際の浮き上がり等によっても光ファイバ２のコア６の間隔にばらつきが生じ接続損失を大きくし、またそれぞれの光導波路と光ファイバの接続部で損失のばらつきが生じるという問題点があった。

【０００４】本発明はこのような課題を解決するために、光導波路と光デバイスの接続において、光導波路の入出力部での光のスポットサイズを大きくすることによって、位置合わせの精度を緩くし、さらに低損失な接続を行える光導波路を提供することを目的とする。

【０００５】

【課題を解決するための手段】このような目的を達成するための第１の発明は、光デバイスと接続を行う光導波路の入出力部において、前記光導波路の光のスポットサイズを大きくするスポットサイズ変換部を設けたことを特徴とする光導波路である。

【０００６】第２の発明は、２つ以上の光導波路と該光導波路と接続を行う光デバイスの接続において、第１の発明の光導波路を用いた接続方法である。

【０００７】第３の発明は、光デバイスとして光ファイバを用い、前記光ファイバの入出力部に光のスポットサイズを大きくするスポットサイズ変換部を設けたことを特徴とする第１の発明の光導波路と光ファイバの接続方法である。

【０００８】第４の発明は、第１の発明の光導波路の入出力部において、光導波路内で光を伝搬させる伝搬用コアと接するようにコアの断面積を前記伝搬用コアより大きくかつ屈折率を小さくした結合用コアを１つ以上設けた構造を特徴とする光導波路である。

【０００９】

【作用】本発明は、光導波路の入出力部での光のスポットサイズを大きくすることによって、光デバイスとの位置合わせの精度を緩くし、２つ以上の光導波路とそれらの光導波路と接続を行う光デバイスを低損失に、また損失のばらつきを少なく接続することが可能となる。

【００１０】

【実施例】図１は本発明の第１実施例を示す斜視図で、図２は第１実施例の光導波路内のコアの斜視図である。光ファイバ２はコア６を拡大したものを用い、光導波路基板１内のコア３も光導波路の入出力端面９に向かうにしたがってコアが大きくなるように構成されている。この光ファイバのコアの拡大部７はクラッド８よりも屈折率を高めるためにコア６にドープされている物質を外部から熱することにより拡散させ、コア６を大きくし、光ファイバの光のスポットサイズを拡大する。一方、光導波路のコアの拡大部４は、光ファイバと同様にコア３内のドープ物質を熱拡散することによって可能である。また、石英系光導波路では光導波路の作製法として火炎堆積法が用いられるが、その際コアを形成する石英系の原料微粒子の噴射量を調整することにより厚み方向にコアの形状を変化させることができ、光導波路の光のスポットサイズを拡大することができる。光ファイバと光導波路のそれぞれの光のスポットサイズを同じ大きさにすることによりほとんど接続損失のない接続が可能となり、さらにスポットサイズが大きいため、光ファイバのコアの拡大部７と光導波路のコアの拡大部４の位置ずれによる接続損失は、スポットサイズを拡大しない場合に比べ

て小さくなる。

【0011】図3は光導波路と光ファイバのコアの位置ずれに対する接続損失を示した図である。スポットサイズを１０μmから２０μmに２倍に拡大した場合には、ある損失値に対して２倍の位置ずれまで許される。また、同じ位置ずれ量であれば、接続損失はより小さくなる。

【0012】図４は本発明の第２実施例の光導波路内のコアの斜視図で、図５は第２実施例の垂直断面図である。光導波路の光のスポットサイズの拡大を行う構造として、方向性結合器の形を用いたものであり、伝搬用コア１０を伝搬する光の等価屈折率と結合用コア１１を伝搬する光の等価屈折率が等しくなるように、クラッド５の屈折率n0 、伝搬用コア１０の屈折率n1 に対し、結合用コア１１の屈折率n2 を選ぶ。それによって、各屈折率、コアの大きさとコア間の距離で決定される結合長Lにおいて、コアの大きい結合用コア１１に入力された光はコアの小さい伝搬用コア１０に効率よく移り、スポットサイズの変換が可能となる。

【0013】図６は本発明の第３実施例の光導波路内のコアの斜視図で、図７は第３実施例の（ａ）は垂直断面図、（ｂ）は水平断面図で、いずれも伝搬用コア１０の中心を含んだ断面図である。光導波路の光の入出力部において光を伝搬させる伝搬用コア１０を囲む形でコアの断面積が伝搬用コア１０より大きく屈折率n2 が$n0< n2 < n1$ となる結合用コア１１が形成され、さらにその結合用コア１１を囲むように屈折率n3 が$n0 < n3 < n2$ となる結合用コア１２が形成される。また、伝搬用コア１０と結合用コア１１が接している部分では、伝搬用コア１０の断面積が入出力端面９に行くにしたがい徐々に小さくなり、また結合用コア１１と結合用コア１２が接している部分でも同様に結合用コア１１の断面積が徐々に小さくなる構造を持つ。以上のような屈折率と構造を用いることにより、結合用コア１２に入力された光は、徐々に光のスポットサイズを小さくしながら結合用コア１１を通り、伝搬用コア１０に移る。その結果、損失を少なくスポットサイズを変換することができる。

【0014】図８は本発明の第４実施例の光導波路内のコアの斜視図である。第３実施例のように伝搬用コア１０を囲むように結合用コア１１が形成されているが、伝搬用コア１０と結合用コア１１の中心がほぼ一致するように構成されている。このように、水平方向と同じように垂直方向に関しても対称性を有する構造をとることにより、結合用コア１１に入力した光をより低損失に伝搬用コア１０に移すことができる。

【0015】図９は本発明の第５実施例の光導波路内のコアの斜視図である。第３、第４実施例では伝搬用コア１０の上面、側面を囲むように結合用コア１１が構成されているが、第５実施例のように伝搬用コア１０の上面（あるいは下面、側面）と結合用コア１１の下面（あるいは上面、側面）が接する構造を用いてもスポットサイズ変換は可能である。

【0016】図１０は本発明の第６実施例の光導波路内のコアの斜視図である。第３、第４第５実施例においては、コアの厚さ方向の大きさは均一である構造としたが、図のように伝搬用コア１０の厚さも変化させてよい。例えば、火炎堆積法によって石英系光導波路を作製する場合は、コアを形成する石英系の原料微粒子の噴射量を調整することによって可能となる。

【0017】図１１は本発明の第７実施例の光導波路内のコアの斜視図である。図のように結合用コア１１の形状も変化させることにより光の伝搬方向に対する断面の屈折率分布が伝搬方向に対して連続的に変化する。それにより光の等価屈折率も連続的に変化し、屈折率の不連続な変化にともなう反射が起こりにくくなる。

【0018】以上の第４、第５、第６、第７実施例において結合用コア１１は１つしか図示していないが、２つ以上ある構造とすることもできる。また、コアが徐々に小さくなる構造では直線状に形状が変化しているが、徐々に小さくなるのであれば曲線的に変化する構造とすることもできる。

【0019】

【発明の効果】以上説明したように、光デバイスと接続を行う光導波路の入出力部において、光導波路の光のスポットサイズを大きくするスポットサイズ変換部を設けることによって、光導波路と光デバイスの位置合わせの精度を緩くし、２つ以上の光導波路とそれらの光導波路と接続を行う光デバイスを低損失に、また損失のばらつきを少なく接続することが可能となる。

【図面の簡単な説明】

【図１】本発明の第１実施例の斜視図である。

【図２】本発明の第１実施例の光導波路内のコアの斜視図である。

【図３】光導波路と光ファイバのコアの位置ずれによる接続損失を示した図である。

【図４】本発明の第２実施例の光導波路内のコアの斜視図である。

【図５】本発明の第２実施例の垂直断面図である。

【図６】本発明の第３実施例の光導波路内のコアの斜視図である。

【図７】本発明の第３実施例に関し、（ａ）は垂直断面図、（ｂ）は水平断面図である。

【図８】本発明の第４実施例の光導波路内のコアの斜視図である。

【図９】本発明の第５実施例の光導波路内のコアの斜視図である。

【図１０】本発明の第６実施例の光導波路内のコアの斜視図である。

【図１１】本発明の第７実施例の光導波路内のコアの斜視図である。

【図１２】従来技術による光導波路と光ファイバの接続構造図である。

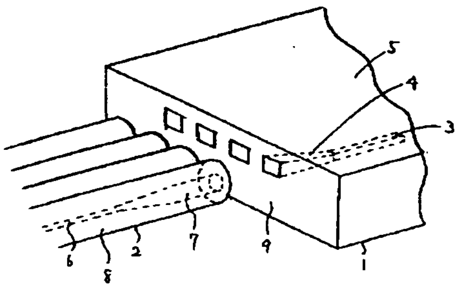
【図１３】光ファイバの整列用Ｖ溝の入出力端面図である。

【符号の説明】

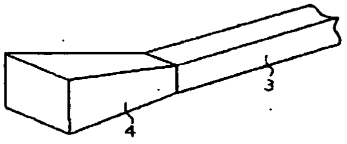
１　光導波路基板
２　光ファイバ
３　光導波路のコア
４　光導波路のコアの拡大部

５　光導波路のクラッド
６　光ファイバのコア
７　光ファイバのコアの拡大部
８　光ファイバのクラッド
９　光導波路の入出力端面
１０　伝搬用コア
１１、１２　結合用コア
１３　Ｖ溝基板
１４　Ｖ溝

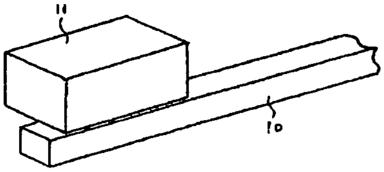
【図１】



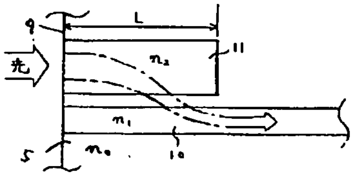
【図２】



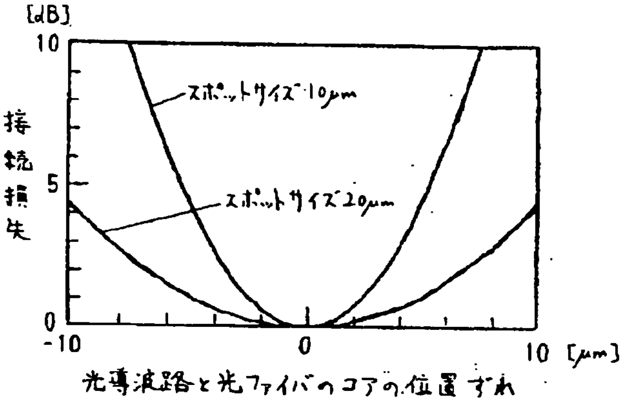
【図４】



【図５】



【図３】



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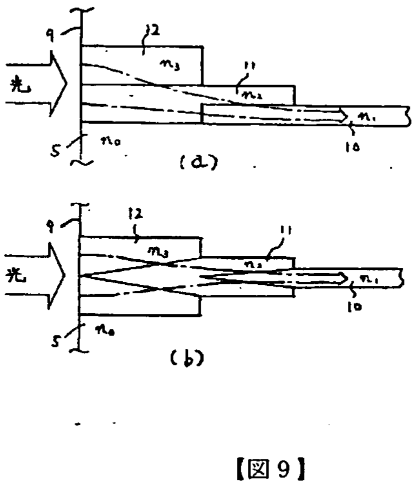
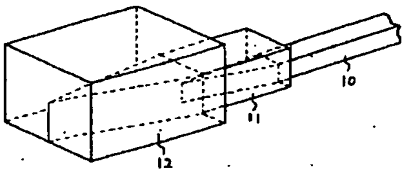
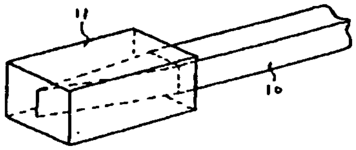


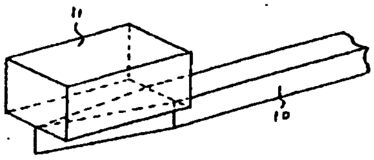
【図６】



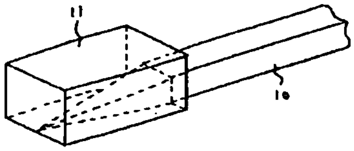
【図８】



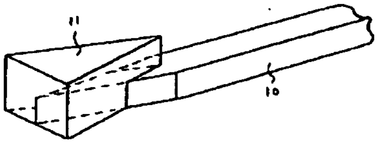
【図９】



【図１０】



【図１１】



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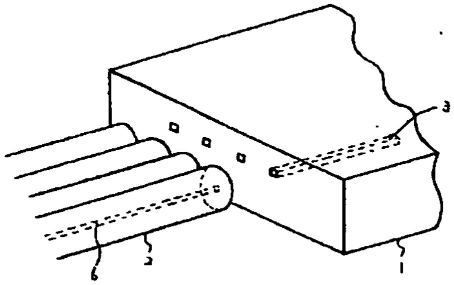

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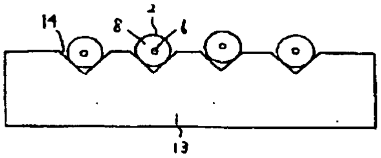

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CLAIMS

[Claim(s)]
[Claim 1] Optical waveguide characterized by expanding a core in the I/O section of said optical waveguide, and for propagation light having spot size expanded, and being outputted and inputted in the optical waveguide by which alignment formation of two or more cores which light spreads was carried out at the optical waveguide substrate.
[Claim 2] Optical waveguide characterized by having formed 1 or two or more cores for association with the cross section larger than this core for propagation, and a small refractive index linked to the edge of said core for propagation in the optical waveguide by which the core for propagation which spreads light was formed in the optical waveguide substrate, and making said core edge for association into the I/O section of optical waveguide.
[Claim 3] For two or more cores which light spreads, said optical waveguide and optical fiber are a contact of optical waveguide and an optical fiber with which it is characterized by expanding [in / on the contact of the optical waveguide and the optical fiber by which the optical waveguide by which alignment formation was carried out, and two or more optical fibers which aligned are connected to an optical waveguide substrate, and / a connection] each core diameter, and for propagation light expanding spot size, and being outputted and inputted.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the optical waveguide for connecting optical I/O with an optical device.
[0002]
[Description of the Prior Art] Drawing 12 is what showed the connection structure of the conventional general optical waveguide and an optical fiber, and used the approach of comparing the core 3 of optical waveguide, and the core 6 of an optical fiber directly.
[0003]
[Problem(s) to be Solved by the Invention] However, when using the above-mentioned connection method, the spot size of the light of optical waveguide and an optical fiber is as small as about 10 micrometers, and in order to make low loss connection, it needs highly precise alignment. Moreover, in connecting 2 or more sets of optical waveguides and optical fibers, it uses what aligned the optical fiber 2 at a V groove substrate 13 like drawing 13 . In order to make loss by connection small at this time, spacing of the core 6 of an optical fiber 2 and the core of optical waveguide other than the highly precise alignment described previously must not be made equal, and dispersion must not be in spacing further. Therefore, although what has a good precision is required, even if V groove 14 is difficult to produce and it can produce it in fact, it will become what has a high price. Moreover, dispersion arose at spacing of the core 6 of an optical fiber 2 further by the relief in the case of immobilization in V groove 14 of an optical fiber 2 etc., and connection loss was enlarged, and there were the degree of the said heart of the core 6 to the magnitude of the clad 8 of an optical fiber 2 or the appearance of a clad 8, its dispersion, and a trouble that dispersion in loss arose in the connection of each optical waveguide and optical fiber.
[0004] In order that this invention may solve such a technical problem, in connection of optical waveguide and an optical device, by enlarging spot size of the light in the I/O section of optical waveguide, precision of alignment is made loose and it aims at offering the optical waveguide which can make still low loss connection.
[0005]
[Means for Solving the Problem] The 1st invention for attaining such a purpose is optical waveguide characterized by preparing the spot-size transducer which enlarges spot size of the light of said optical waveguide in the I/O section of the optical waveguide linked to an optical device.
[0006] The 2nd invention is a connection method using the optical waveguide of the 1st invention in connection of the optical device linked to two or more optical waveguides and these optical waveguides.

[0007] The 3rd invention is the optical waveguide of the 1st invention and the connection method of an optical fiber which are characterized by preparing the spot-size transducer which enlarges spot size of light in the I/O section of said optical fiber, using an optical fiber as an optical device.
[0008] The 4th invention is optical waveguide characterized by the structure which prepared one or more cores for association which made the refractive index small more greatly [so that the core for

propagation which makes light spread within optical waveguide may be touched / cross section / of a core] than said core for propagation in the I/O section of the optical waveguide of the 1st invention.
[0009]
[Function] By enlarging spot size of the light in the I/O section of optical waveguide, this invention makes precision of alignment with an optical device loose, and becomes possible [connecting dispersion in again loss of the optical device linked to two or more optical waveguides and those optical waveguides in low loss few].
[0010]
[Example] Drawing 1 is the perspective view showing the 1st example of this invention, and drawing 2 is the perspective view of the core in the optical waveguide of the 1st example. Using what expanded the core 6, the optical fiber 2 is constituted so that a core may become large, as the core 3 in the optical waveguide substrate 1 also goes to the I/O end face 9 of optical waveguide. The limb 7 of the core of this optical fiber is diffused by heating from the outside the matter doped by the core 6, in order to raise a refractive index rather than a clad 8, it enlarges a core 6, and expands the spot size of the light of an optical fiber. On the other hand, the limb 4 of the core of optical waveguide is possible by carrying out thermal diffusion of the dope matter in a core 3 like an optical fiber. Moreover, although the flame depositing method is used as a method of producing optical waveguide in quartz system optical waveguide, by adjusting the injection quantity of the raw material particle of the quartz system which forms a core in that case, the configuration of a core can be changed in the thickness direction and the spot size of the light of optical waveguide can be expanded. The connection loss which does not almost have connection loss according [become connectable, and] to a location gap of the limb 7 of the core of an optical fiber and the limb 4 of the core of optical waveguide since spot size is still larger becomes small compared with the case where spot size is not expanded, by making spot size of each light of an optical fiber and optical waveguide into the same magnitude.
[0011] Drawing 3 is drawing having shown the connection loss over a location gap of the core of optical waveguide and an optical fiber. When spot size is expanded to 20 micrometers twice from 10 micrometers, it is allowed to a twice as many location gap as this to a certain loss value. Moreover, connection loss will become smaller if it is the same amount of location gaps.
[0012] Drawing 4 is the perspective view of the core in the optical waveguide of the 2nd example of this invention, and drawing 5 is the vertical cross section of the 2nd example. They are the refractive index n0 of a clad 5, and the refractive index n1 of the core 10 for propagation so that the effective refractive index of the light which spreads the core 10 for propagation, and the effective refractive index of the light which spreads the core 11 for association may become equal, using the form of a directional coupler as structure of expanding spot size of the light of optical waveguide. It receives and is the refractive index n2 of the core 11 for association. It chooses. By it, it moves to the small core 10 for propagation of a core efficiently, and the light inputted into the large core 11 for association of a core in the bond length L determined in each refractive index, the magnitude of a core, and the distance between cores becomes it convertible [spot size].
[0013] Drawing 6 is the perspective view of the core in the optical waveguide of the 3rd example of this invention, and drawing 7 is the sectional view where the vertical cross section and (b) are horizontal sectional views, and (a) of the 3rd example all included the core of the core 10 for propagation. The cross section of a core is a refractive index n2 more greatly than the core 10 for propagation in the form surrounding the core 10 for propagation which makes light spread in the I/O section of the light of optical waveguide. $n0<n2<n1$ It is a refractive index n3 so that the becoming core 11 for association may be formed and the core 11 for association may be surrounded further. $n0<n3<n2$ The becoming core 12 for association is formed. Moreover, in the part with which the core 10 for propagation and the core 11 for association are in contact, the cross section of the core 11 for association has similarly the structure which becomes small gradually in the part with which it became gradually small as the cross section of the core 10 for propagation went to the I/O end face 9, and the core 11 for association and the core 12 for association are in contact. By using above refractive indexes and structures, the light inputted into the core 12 for association passes along the core 11 for association, making spot size of light small

gradually, and it moves from it to the core 10 for propagation. Consequently, spot size is [loss] convertible few.

[0014] Drawing 8 is the perspective view of the core in the optical waveguide of the 4th example of this invention. The core 11 for association is formed so that the core 10 for propagation may be surrounded like the 3rd example, but it is constituted so that the core of the core 10 for propagation and the core 11 for association may be mostly in agreement. Thus, the light inputted into the core 11 for association is more movable to low loss at the core 10 for propagation by taking the structure of having symmetric property about a perpendicular direction horizontally similarly.

[0015] Drawing 9 is the perspective view of the core in the optical waveguide of the 5th example of this invention. The core 11 for association consists of the 3rd and 4th example so that the top face of the core 10 for propagation and a side face may be surrounded, but even if it uses the structure where the top face (or an inferior surface of tongue, a side face) of the core 10 for propagation and the inferior surface of tongue (or a top face, a side face) of the core 11 for association touch like the 5th example, spot-size conversion is possible.

[0016] Drawing 10 is the perspective view of the core in the optical waveguide of the 6th example of this invention. the [3rd] -- in the 4 5th example, although magnitude of the thickness direction of a core was made into uniform structure, as shown in drawing, the thickness of the core 10 for propagation may also be changed. For example, when producing quartz system optical waveguide by the flame depositing method, it becomes possible by adjusting the injection quantity of the raw material particle of the quartz system which forms a core.

[0017] Drawing 11 is the perspective view of the core in the optical waveguide of the 7th example of this invention. Refractive-index distribution of the cross section to the propagation direction of light changes continuously to the propagation direction by changing the configuration of the core 11 for association, as shown in drawing. Thereby, the effective refractive index of light also changes continuously and the reflection accompanying a discontinuous change of a refractive index stops being able to happen easily.

[0018] Although the core 11 for association is illustrating only one in the above example [4th, 5th, 6th, and 7th], two or more can also be made into a certain structure. Moreover, although the configuration is changing in the shape of a straight line with the structure where a core becomes small gradually, if it becomes small gradually, it can also consider as the structure of changing rounded.

[0019]

[Effect of the Invention] As explained above, in the I/O section of the optical waveguide linked to an optical device, by preparing the spot-size transducer which enlarges spot size of the light of optical waveguide, precision of the alignment of optical waveguide and an optical device is made loose, and it becomes possible to connect dispersion in again loss of the optical device linked to two or more optical waveguides and those optical waveguides in low loss few.

[Translation done.]

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TECHNICAL FIELD

[Industrial Application] This invention relates to the optical waveguide for connecting optical I/O with an optical device.

[Translation done.]

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PRIOR ART

[Description of the Prior Art] Drawing 12 is what showed the connection structure of the conventional general optical waveguide and an optical fiber, and used the approach of comparing the core 3 of optical waveguide, and the core 6 of an optical fiber directly.

[Translation done.]

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EFFECT OF THE INVENTION

[Effect of the Invention] As explained above, in the I/O section of the optical waveguide linked to an optical device, by preparing the spot-size transducer which enlarges spot size of the light of optical waveguide, precision of the alignment of optical waveguide and an optical device is made loose, and it becomes possible to connect dispersion in again loss of the optical device linked to two or more optical waveguides and those optical waveguides in low loss few.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, when using the above-mentioned connection method, the spot size of the light of optical waveguide and an optical fiber is as small as about 10 micrometers, and in order to make low loss connection, it needs highly precise alignment. Moreover, in connecting 2 or more sets of optical waveguides and optical fibers, it uses what aligned the optical fiber 2 at a V groove substrate 13 like drawing 13 . In order to make loss by connection small at this time, spacing of the core 6 of an optical fiber 2 and the core of optical waveguide other than the highly precise alignment described previously must not be made equal, and dispersion must not be in spacing further. Therefore, although what has a good precision is required, even if V groove 14 is difficult to produce and it can produce it in fact, it will become what has a high price. Moreover, dispersion arose at spacing of the core 6 of an optical fiber 2 further by the relief in the case of immobilization in V groove 14 of an optical fiber 2 etc., and connection loss was enlarged, and there were the degree of the said heart of the core 6 to the magnitude of the clad 8 of an optical fiber 2 or the appearance of a clad 8, its dispersion, and a trouble that dispersion in loss arose in the connection of each optical waveguide and optical fiber.
[0004] In order that this invention may solve such a technical problem, in connection of optical waveguide and an optical device, by enlarging spot size of the light in the I/O section of optical waveguide, precision of alignment is made loose and it aims at offering the optical waveguide which can make still low loss connection.

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MEANS

[Means for Solving the Problem] The 1st invention for attaining such a purpose is optical waveguide characterized by preparing the spot-size transducer which enlarges spot size of the light of said optical waveguide in the I/O section of the optical waveguide linked to an optical device.
[0006] The 2nd invention is a connection method using the optical waveguide of the 1st invention in connection of the optical device linked to two or more optical waveguides and these optical waveguides.

[0007] The 3rd invention is the optical waveguide of the 1st invention and the connection method of an optical fiber which are characterized by preparing the spot-size transducer which enlarges spot size of light in the I/O section of said optical fiber, using an optical fiber as an optical device.
[0008] The 4th invention is optical waveguide characterized by the structure which prepared one or more cores for association which made the refractive index small more greatly [so that the core for propagation which makes light spread within optical waveguide may be touched / cross section / of a core] than said core for propagation in the I/O section of the optical waveguide of the 1st invention.

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OPERATION

[Function] By enlarging spot size of the light in the I/O section of optical waveguide, this invention makes precision of alignment with an optical device loose, and becomes possible [connecting dispersion in again loss of the optical device linked to two or more optical waveguides and those optical waveguides in low loss few].

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EXAMPLE

[Example] Drawing 1 is the perspective view showing the 1st example of this invention, and drawing 2 is the perspective view of the core in the optical waveguide of the 1st example. Using what expanded the core 6, the optical fiber 2 is constituted so that a core may become large, as the core 3 in the optical waveguide substrate 1 also goes to the I/O end face 9 of optical waveguide. The limb 7 of the core of this optical fiber is diffused by heating from the outside the matter doped by the core 6, in order to raise a refractive index rather than a clad 8, it enlarges a core 6, and expands the spot size of the light of an optical fiber. On the other hand, the limb 4 of the core of optical waveguide is possible by carrying out thermal diffusion of the dope matter in a core 3 like an optical fiber. Moreover, although the flame depositing method is used as a method of producing optical waveguide in quartz system optical waveguide, by adjusting the injection quantity of the raw material particle of the quartz system which forms a core in that case, the configuration of a core can be changed in the thickness direction and the spot size of the light of optical waveguide can be expanded. The connection loss which does not almost have connection loss according [become connectable, and] to a location gap of the limb 7 of the core of an optical fiber and the limb 4 of the core of optical waveguide since spot size is still larger becomes small compared with the case where spot size is not expanded, by making spot size of each light of an optical fiber and optical waveguide into the same magnitude.
[0011] Drawing 3 is drawing having shown the connection loss over a location gap of the core of optical waveguide and an optical fiber. When spot size is expanded to 20 micrometers twice from 10 micrometers, it is allowed to a twice as many location gap as this to a certain loss value. Moreover, connection loss will become smaller if it is the same amount of location gaps.
[0012] Drawing 4 is the perspective view of the core in the optical waveguide of the 2nd example of this invention, and drawing 5 is the vertical cross section of the 2nd example. They are the refractive index n0 of a clad 5, and the refractive index n1 of the core 10 for propagation so that the effective refractive index of the light which spreads the core 10 for propagation, and the effective refractive index of the light which spreads the core 11 for association may become equal, using the form of a directional coupler as structure of expanding spot size of the light of optical waveguide. It receives and is the refractive index n2 of the core 11 for association. It chooses. By it, it moves to the small core 10 for propagation of a core efficiently, and the light inputted into the large core 11 for association of a core in the bond length L determined in each refractive index, the magnitude of a core, and the distance between cores becomes it convertible [spot size].
[0013] Drawing 6 is the perspective view of the core in the optical waveguide of the 3rd example of this invention, and drawing 7 is the sectional view where the vertical cross section and (b) are horizontal sectional views, and (a) of the 3rd example all included the core of the core 10 for propagation. The cross section of a core is a refractive index n2 more greatly than the core 10 for propagation in the form surrounding the core 10 for propagation which makes light spread in the I/O section of the light of optical waveguide. $n0<n2<n1$ It is a refractive index n3 so that the becoming core 11 for association may be formed and the core 11 for association may be surrounded further. $n0<n3<n2$ The becoming core 12 for association is formed. Moreover, in the part with which the core 10 for propagation and the

core 11 for association are in contact, the cross section of the core 11 for association has similarly the structure which becomes small gradually in the part with which it became gradually small as the cross section of the core 10 for propagation went to the I/O end face 9, and the core 11 for association and the core 12 for association are in contact. By using above refractive indexes and structures, the light inputted into the core 12 for association passes along the core 11 for association, making spot size of light small gradually, and it moves from it to the core 10 for propagation. Consequently, spot size is [loss] convertible few.

[0014] Drawing 8 is the perspective view of the core in the optical waveguide of the 4th example of this invention. The core 11 for association is formed so that the core 10 for propagation may be surrounded like the 3rd example, but it is constituted so that the core of the core 10 for propagation and the core 11 for association may be mostly in agreement. Thus, the light inputted into the core 11 for association is more movable to low loss at the core 10 for propagation by taking the structure of having symmetric property about a perpendicular direction horizontally similarly.

[0015] Drawing 9 is the perspective view of the core in the optical waveguide of the 5th example of this invention. The core 11 for association consists of the 3rd and 4th example so that the top face of the core 10 for propagation and a side face may be surrounded, but even if it uses the structure where the top face (or an inferior surface of tongue, a side face) of the core 10 for propagation and the inferior surface of tongue (or a top face, a side face) of the core 11 for association touch like the 5th example, spot-size conversion is possible.

[0016] Drawing 10 is the perspective view of the core in the optical waveguide of the 6th example of this invention. the [3rd] -- in the 4 5th example, although magnitude of the thickness direction of a core was made into uniform structure, as shown in drawing, the thickness of the core 10 for propagation may also be changed. For example, when producing quartz system optical waveguide by the flame depositing method, it becomes possible by adjusting the injection quantity of the raw material particle of the quartz system which forms a core.

[0017] Drawing 11 is the perspective view of the core in the optical waveguide of the 7th example of this invention. Refractive-index distribution of the cross section to the propagation direction of light changes continuously to the propagation direction by changing the configuration of the core 11 for association, as shown in drawing. Thereby, the effective refractive index of light also changes continuously and the reflection accompanying a discontinuous change of a refractive index stops being able to happen easily.

[0018] Although the core 11 for association is illustrating only one in the above example [4th, 5th, 6th, and 7th], two or more can also be made into a certain structure. Moreover, although the configuration is changing in the shape of a straight line with the structure where a core becomes small gradually, if it becomes small gradually, it can also consider as the structure of changing rounded.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the perspective view of the 1st example of this invention.
[Drawing 2] It is the perspective view of the core in the optical waveguide of the 1st example of this invention.
[Drawing 3] It is drawing having shown the connection loss by location gap of the core of optical waveguide and an optical fiber.
[Drawing 4] It is the perspective view of the core in the optical waveguide of the 2nd example of this invention.
[Drawing 5] It is the vertical cross section of the 2nd example of this invention.
[Drawing 6] It is the perspective view of the core in the optical waveguide of the 3rd example of this invention.
[Drawing 7] About the 3rd example of this invention, (a) is the vertical cross section and (b) is a horizontal sectional view.
[Drawing 8] It is the perspective view of the core in the optical waveguide of the 4th example of this invention.
[Drawing 9] It is the perspective view of the core in the optical waveguide of the 5th example of this invention.
[Drawing 10] It is the perspective view of the core in the optical waveguide of the 6th example of this invention.
[Drawing 11] It is the perspective view of the core in the optical waveguide of the 7th example of this invention.
[Drawing 12] It is connection structural drawing of optical waveguide and an optical fiber by the conventional technique.
[Drawing 13] It is the I/O end view of the V groove for alignment of an optical fiber.
[Description of Notations]
1 Optical Waveguide Substrate
2 Optical Fiber
3 Core of Optical Waveguide
4 Limb of Core of Optical Waveguide
5 Clad of Optical Waveguide
6 Core of Optical Fiber
7 Limb of Core of Optical Fiber
8 Clad of Optical Fiber
9 I/O End Face of Optical Waveguide
10 Core for Propagation
11 12 Core for association
13 V Groove Substrate
14 V Groove

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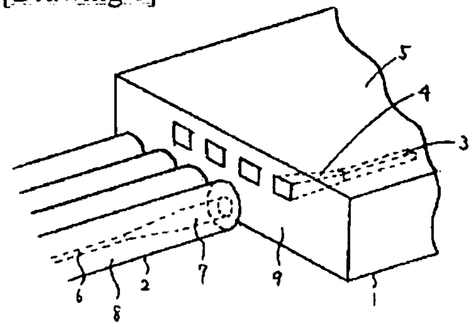
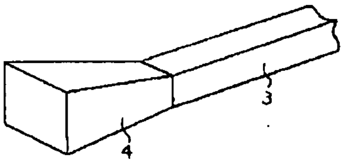
DRAWINGS

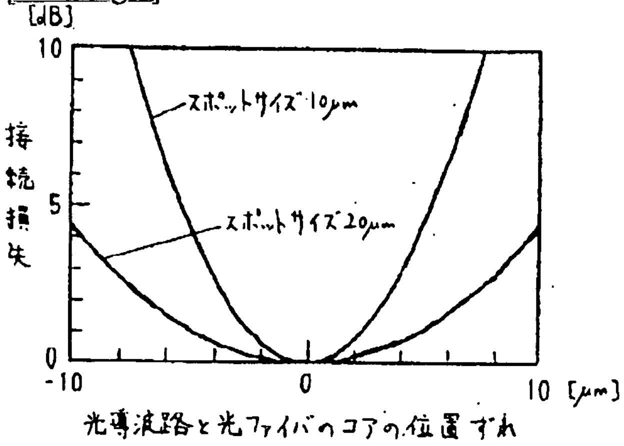
[Drawing 1]



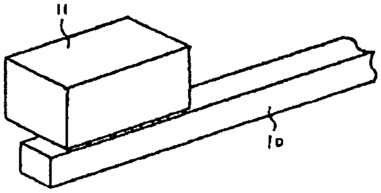
[Drawing 2]



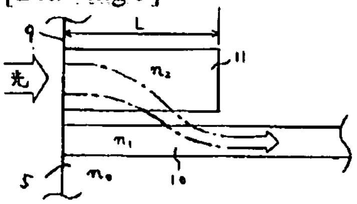
[Drawing 3]



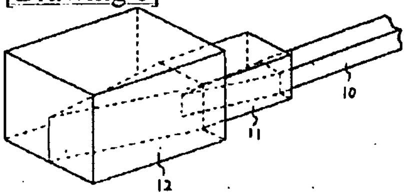
[Drawing 4]



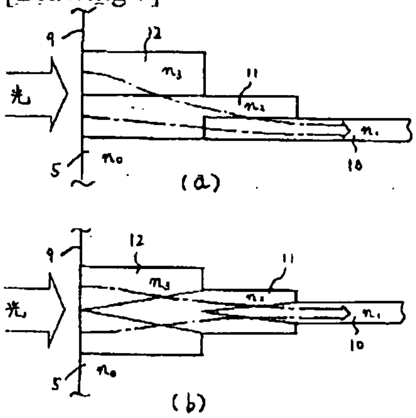
[Drawing 5]



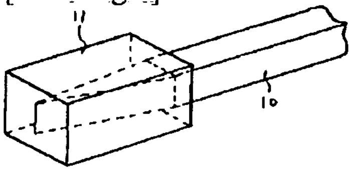
[Drawing 6]



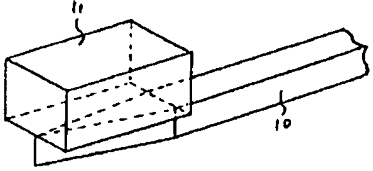
[Drawing 7]



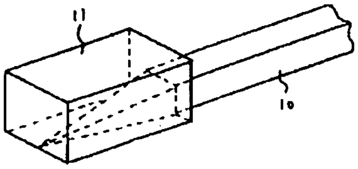
[Drawing 8]



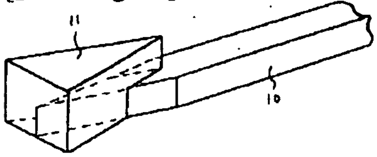
[Drawing 9]



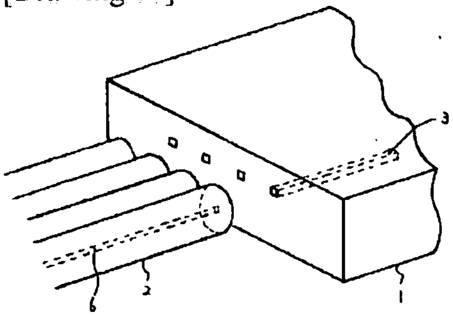
[Drawing 10]



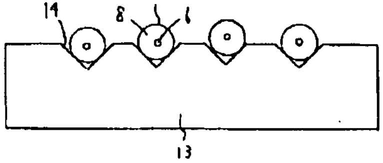
[Drawing 11]



[Drawing 12]



[Drawing 13]



[Translation done.]